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TRANSMITTAL LETTER			Docket Number 67097-001
Application Number 09/803,191	Filing Date 9 March 2001	Examiner	Group Art Unit 3672
Invention Title <i>ADI Centralizer</i>			


3

To the Assistant Commissioner for Patents, Box Missing Parts:

Transmitted herewith for filing in the patent application of **Ian Alastair Kirk, William Barron, Alistair Bertram Clark, Arron Rimmer and Barry Newton** are:

- ☒ submission of missing parts and notice of missing parts formalities letter - part 2
- ☒ executed declaration and power of attorney of the inventors
- ☒ assignment of the invention to Downhole Products PLC and recordation Form PTO-1595
- ☒ a certified copy of United Kingdom application 0005740.6 filed 10 March 2000
- ☒ other: **return receipt postcard**
- ☒ A check in the amount of **\$65** to cover the missing parts filing fee is enclosed.
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Respectfully submitted,


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The Patent Office

Cardiff Road
Newport
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1. Your reference

P25625/JLU/CWA/JAL

2. Patent application number

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0005740.6

10 MAR 2000

3. Full name, address and postcode of the or of
each applicant (underline all surnames)

Downhole Products PLC
Badentoy Road
Badentoy Park
Portlethen
Aberdeen
AB12 4YA

Patents ADP number (if you know it)

If the applicant is a corporate body, give the
country/state of its incorporation

United Kingdom

7159171002 ET

4. Title of the invention

"Centraliser"

5. Name of your agent (if you have one)

Murgitroyd & Company

"Address for service" in the United Kingdom
to which all correspondence should be sent
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373 Scotland Street
GLASGOW
G5 8QA

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1

1 "Centraliser"

2

3 This invention relates to a centraliser, and
4 particularly to a centraliser for use in centralising
5 casing or other tubulars such as drillpipe or screens
6 in an oil or gas well.

7

8 In drilling wellbores for oil and gas it is common to
9 drill through the formation and subsequently to case
10 the open bore with a liner or a casing (typically of
11 metal) and to cement the liner or casing in place.
12 Centralisers are used around the liner or casing in
13 order to keep it in the middle of the borehole and to
14 allow free flow of cement through the annulus between
15 the casing and the wall of the borehole. This acts as
16 a sealant and also as a mechanical support for the
17 casing. Centralisers have therefore been adapted for
18 attachment around the outer diameter of a liner or
19 casing prior to the cement job. Centralisers can also
20 be used to keep a screen in a central location in the
21 wellbore as it passes through a formation.

22

2

1 According to the present invention there is provided a
2 centraliser comprising an annular body with a bore
3 extending through the body and one or more blades, the
4 centraliser being adapted to fit around a tubular to be
5 centralised, and comprising a tempered metal.

6
7 The invention also provides a method of manufacturing a
8 centraliser, the method comprising forming the
9 centraliser from metal and tempering the metal
10 centraliser.

11
12 The metal is preferably austenitised, typically by
13 heating the metal to 800-960°C typically for 1 to 4
14 hours. Preferably the metal is also austempered by
15 quenching in molten salt for 2-4 hours at 200-400°C and
16 preferably air dried. Preferably the salt is a mixture
17 of potassium nitrate and sodium nitrite. Typically an
18 equimolar mixture of these salts is used. Typically
19 the entire centraliser is formed from the tempered
20 metal. Any other tempering process can be used to
21 temper the metal. Suitable methods can be found in
22 Metals Handbook Vol 1-3 1990-1991 published by ASM
23 International.

24
25 The metal is preferably ductile metal and most
26 preferably comprises ductile iron, although any metal
27 that can be tempered will suffice. Castable metals are
28 preferred.

29

3

1 Alloys can be used as the metal of the centraliser, and
2 in particular, iron can be alloyed with Mo, Cu or Ni to
3 enhance the hardness of the metal.

4

5 The iron is normally a cast iron with preferably
6 3.2-3.8% C most preferably 3.6% C and 2.2-2.8% Si most
7 preferably 2.5%. Typically other alloying elements are
8 added in very small quantities (<0.04%) which may
9 include Mg, Mn, Cu, Ni, Mo, Sn, Sb, P, S, O, Cr, Ti, V,
10 Al, As, Bi, B, Cd, Pb, Se, Te. Elements such as Be,
11 Ca, Sr, Ba, Y, La, Ce may be added in lieu of Mg.

12

13 Grades 1-5 of ADI are preferred according to
14 ASTM 897M-90.

15

16 The centraliser is typically cast into the desired
17 shape with the annular body and blades, optionally
18 shaped e.g. by filing or grinding, and then tempered,
19 e.g. by austempering the whole centraliser. The
20 tempering process can be extended in accordance with
21 the ratio of ferrite:pearlite in the metal. Metals
22 with a higher ferrite:pearlite ratio may need longer
23 tempering process times. The centraliser is typically
24 cast in a slightly different shape (e.g. with an oval-
25 shaped annular body) to that of the final product (e.g.
26 a cylindrical annular body) to allow for distortions
27 occurring during the casting and tempering process.
28 Typically the centraliser shrinks by e.g. 1-2% during
29 casting and typically expands by e.g. 1-2% after heat
30 treatment. Therefore the centraliser is typically cast
31 to a different size than finally required.

1 The blades are preferably circumferentially distributed
2 around the outer surface of the centraliser, and
3 preferably each extend parallel to the bore of the
4 centraliser. The blades are preferably disposed
5 opposite one another on the centraliser body. There
6 may be four, five or six such blades or some other
7 number.

8

9 The method of invention is typically carried out by
10 high temperature casting in a sand casting mould. The
11 blades of the centraliser are typically formed by
12 indentations in the mould and by protrusions on a blank
13 set in the mould. The blade shapes are typically
14 profiled to facilitate removal of the cast centraliser
15 from the mould, and are typically profiled differently
16 from one another. The centraliser is typically formed
17 by two half-moulds adapted to engage one another so as
18 to form the centraliser between the two half-moulds.
19 Typically the join between the two moulds is aligned
20 with a blade of the centraliser.

21

22 The tubular can be drillpipe, casing, liner, production
23 tubing, coil tubing and may include slotted and
24 predrilled and/or plugged tubing, screens and
25 perforating strings etc for disposal in the reservoir
26 payzone, in which case the centraliser would maintain
27 the screen in the middle of the uncased borehole.

28

29 An embodiment of the invention will now be described by
30 way of example and with reference to the accompanying
31 drawings in which:-

5

1 Fig. 1 is a front elevation of a centraliser;

2

3 Fig. 2 is a side perspective view of the Fig. 1
4 centraliser;

5

6 Fig. 3 is a plan view of the Fig. 1 centraliser;
7 and,

8

9 Fig. 4 is a perspective exploded view of a sand
10 cast used to manufacture the Fig. 1 centraliser.

11

12 A casing centraliser 10 comprises a unitary moulded
13 cylindrical body 12, and an array of six equiangularly-
14 spaced blades 14 integrally formed with the body 12. A
15 cylindrical bore 16 extends axially through the body
16 12, and has a substantially uniform diameter
17 dimensioned to be a clearance fit around the well bore
18 casing, or other tubular to which the centraliser is
19 applied.

20

21 Each of the blades 14 not only extends between
22 longitudinally opposite ends of the body 12, but also
23 extends circumferentially around the periphery of the
24 centraliser 10. The skewing of the blades 14 ensures
25 that their respective outer edges 18 collectively
26 provide a generally uniform well bore-contacting
27 surface around the circumference of the centraliser 10.

28

29 Each of the blades 14 has a respective radially inner
30 root 19 integral with the body 12. In each of the
31 blades 14, the root 19 has a greater circumferential

6

1 width than the outer edge 18, i.e. the cross-section of
2 each blade 14 tapers towards the well bore-contacting
3 periphery of the centraliser 10. The individual and
4 collective shapes of the blades 14, and of the
5 longitudinal fluid flow passages defined between
6 adjacent pairs of the blades 14, gives the centraliser
7 10 improved flow characteristics and minimises the
8 build-up of trapped solids during use of the
9 centraliser 10. The tapered cross-section of the
10 blades also eases removal of the centraliser from the
11 cast during manufacture.

12
13 Longitudinally opposite ends of the blades 14 and of
14 the body 12 are chamfered to assist in movement of the
15 centraliser 10 up/down a well bore.

16
17 The blades 14 of the centraliser 10 keep the tubular
18 centralised within the borehole, and bear against the
19 wall of the borehole to reduce friction should the
20 tubular be moved.

21
22 It is preferred that the entire centraliser 10 be
23 fabricated as a one-piece article (although the blades
24 14 could be separately formed and subsequently attached
25 to the body 12 by any suitable means). The centraliser
26 10 is typically formed from ductile iron and moulded in
27 a sand cast 20.

28 The sand cast 20 is used to cast mould the centraliser
29 10. The sand cast 20 is made up from two parts 21a,
30 21b with semi-circular cross section.

31

7

1 An indent 22 to correspond to the outer face of the
2 centraliser 10 is first cut out from the sand 25 in
3 each part 21a, 21b of the cast 20. Further
4 indentations are then cut into the indent 22 to form
5 outer faces of blades 14 in the cast centraliser. An
6 inner core 23 is secured in support holes 24 and is
7 suspended in the indent 22 without touching the walls
8 thereof so as to displace metal from an axial bore of
9 the centraliser 10 and provide on its outer surface a
10 blank for the inner surface of the centraliser 10. The
11 core 23 is therefore located in the mould where the
12 bore 16 of the centraliser will be in the finished
13 article. The upper cast 21b is joined to the lower
14 cast 21a before the metal is poured so that the
15 complete shape cut out of the sand 25 is that of the
16 centraliser 10. Normally the join between the upper
17 21b and lower 21a parts of the cast along or close to a
18 blade 14.

19

20 As the material will shrink on cooling and its
21 dimensions will be altered during heat treatment, the
22 shape of the indent 22 can first be precisely
23 determined from shrinkage calculations and by
24 measurements of previous casts. The material being
25 moulded will also affect the shrinkage characteristics.
26 Typically the centraliser will expand during the
27 tempering process. As the shrinkage after casting and
28 particularly the expansion after tempering, is
29 non-uniform a specifically calculated indent 22 is used
30 to make the centraliser 10.

31

8

1 The sides of the indent 22 curve inwards to allow the
2 mould to be removed from the centraliser after the
3 material has solidified. The blades 14 are tapered to
4 ease the removal of the centraliser 10 from the mould.

5
6 Molten ductile iron is poured through the hole 26 and
7 into the indent 22. The iron is allowed to cool and so
8 the centraliser 10 is formed. The sand cast 20 can
9 then be removed from the centraliser 10. The tapered
10 sides of the indent 22 and tapered blades 14 allow the
11 cast to be removed relatively easily.

12
13 The iron is normally a cast iron with between 3.2-3.8%
14 C most preferably 3.6% C and 2.2-2.8% Si most
15 preferably 2.5%. C and Si to an extent, encourage
16 similar properties in the material and so the total
17 amount of %C and (1/3)%Si can be considered as a carbon
18 equivalent(CE). The total CE ranges are typically
19 around 4.3% for thick sections (over 2"), to 4.6% for
20 thin sections, (0.1"-0.5").

21
22 Optionally other alloying elements are added in very
23 small quantities which may include Mn(typically 0.35-
24 0.60%), Mg ((%S x 0.76) + 0.025% +/- 0.005%), Sn (0.02
25 +/-0.003%), Sb (0.002% +/- 0.0003%), P (0.04%), S
26 (0.02%), O (50ppm), Cr (0.10%), Ti(0.040%), V (0.10%),
27 Al (0.050%), As (0.020%), Bi (0.002%), B (0.002%), Cd
28 (0.005%), Pb (0.002%), Se (0.030%), Te (0.020%).

29
30 To increase hardenability for a heavier section (i.e.
31 greater than 19mm), Cu(up to 0.8%), Ni(up to 2%) and

1 Mo (up to 0.3%) may be added. Increased hardenability
2 prevents the formation of pearlite during quenching.
3 Mg is added to encourage nodulisation. Elements such
4 as Be, Ca, Sr, Ba, Y, La, Ce may be added in lieu of or
5 in addition to Mg. The total weight of nodulising
6 elements is not normally more than 0.06%.

7
8 The castings should be free of non-metallic inclusions,
9 carbides, shrink and dross. Proper purchasing, storage
10 and use of charge material will minimise the unwanted
11 occurrence of carbides and gas defects. Proper
12 moulding control will minimise surface defects and
13 other sub-surface discontinuities. The casting should
14 be properly gated and poured using consistent and
15 effective treatment and inoculation techniques to
16 ensure shrink free castings. Preferably the nodule
17 count will be at least 100/mm² and the nodularity at
18 least 85%.

19
20 After casting the centraliser 10 is tempered by a heat
21 treatment to produce a stronger, harder material. The
22 ductile iron used to produce the centraliser 10,
23 normally contains pearlite and ferrite which are
24 irregular in shape and vary substantially in size.
25 This reduces hardness and strength. The centraliser is
26 heated to the austenite phase i.e. between 815°C and
27 955°C depending on the precise concentration of the
28 alloys. The centraliser is held for 1-4 hours in the
29 austenite phase, the precise time required depends on
30 the size of the centraliser and the amount of ferrite

10

1 in the metal; a higher concentration of ferrite may
2 require more time at these elevated temperatures. When
3 the austenite is saturated with carbon the centraliser
4 is then austempered. To achieve this the metal is
5 quenched in molten salt at 240°C - 400°C. The rate of
6 cooling should be sufficient to avoid the formation of
7 ferrite or pearlite. The metal is held in the salt for
8 1-4h to allow the austenite to change to ausferrite.
9 The molten salt is normally an equimolar mixture of
10 potassium nitrate/sodium nitrite although other salts
11 may be used.

12

13 The net effect of the heat treatment is to cause the
14 ferrite and pearlite phases to be converted into
15 ausferrite. Ausferrite is a stabilised carbon enriched
16 austenite and acicular ferrite non-equilibrium phase.

17

18 This material is twice as strong as conventional
19 ductile iron. Another advantage is that this material
20 is less dense than conventional steel and so is up to
21 10% lighter. A further advantage is the increased
22 hardenability compared with steel. The cost of
23 manufacturing in this way is also reduced.

24

25 Alternatively, other heat treatments may be used to
26 adapt the microstructure and phase composition of the
27 metal 22.

28

29 For example to increase ductility the material may be
30 heated up to 700-730°C. After 1-4 hours the material is
31 quenched in molten salt. This reduces the amount of

11

1 coarse pearlite and increases the amount of spheriodite
2 in the structure.

3

4 A further alternative may be to anneal the steel. The
5 centraliser is again heated into the austenite phase
6 but is then allowed to cool gradually. This produces a
7 microstructure with small and uniform grains.

8

9 Modifications and improvements can be incorporated
10 without departing from the scope of the invention.

11

1/4

10

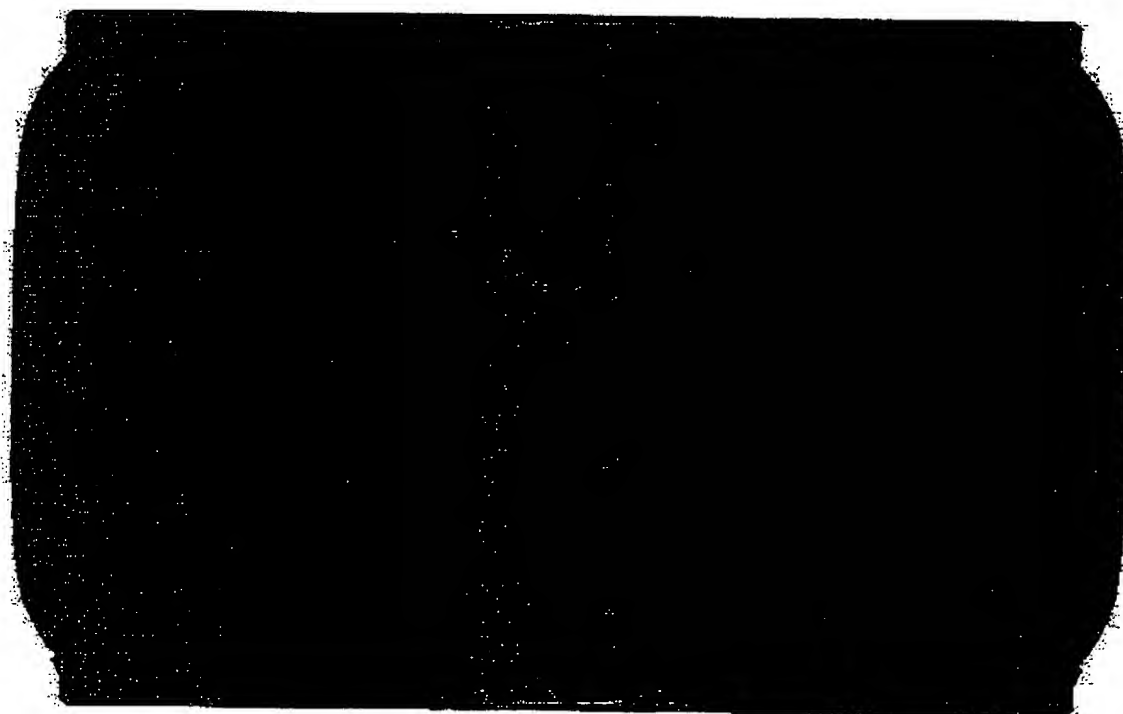


Fig. 1

12

2/4

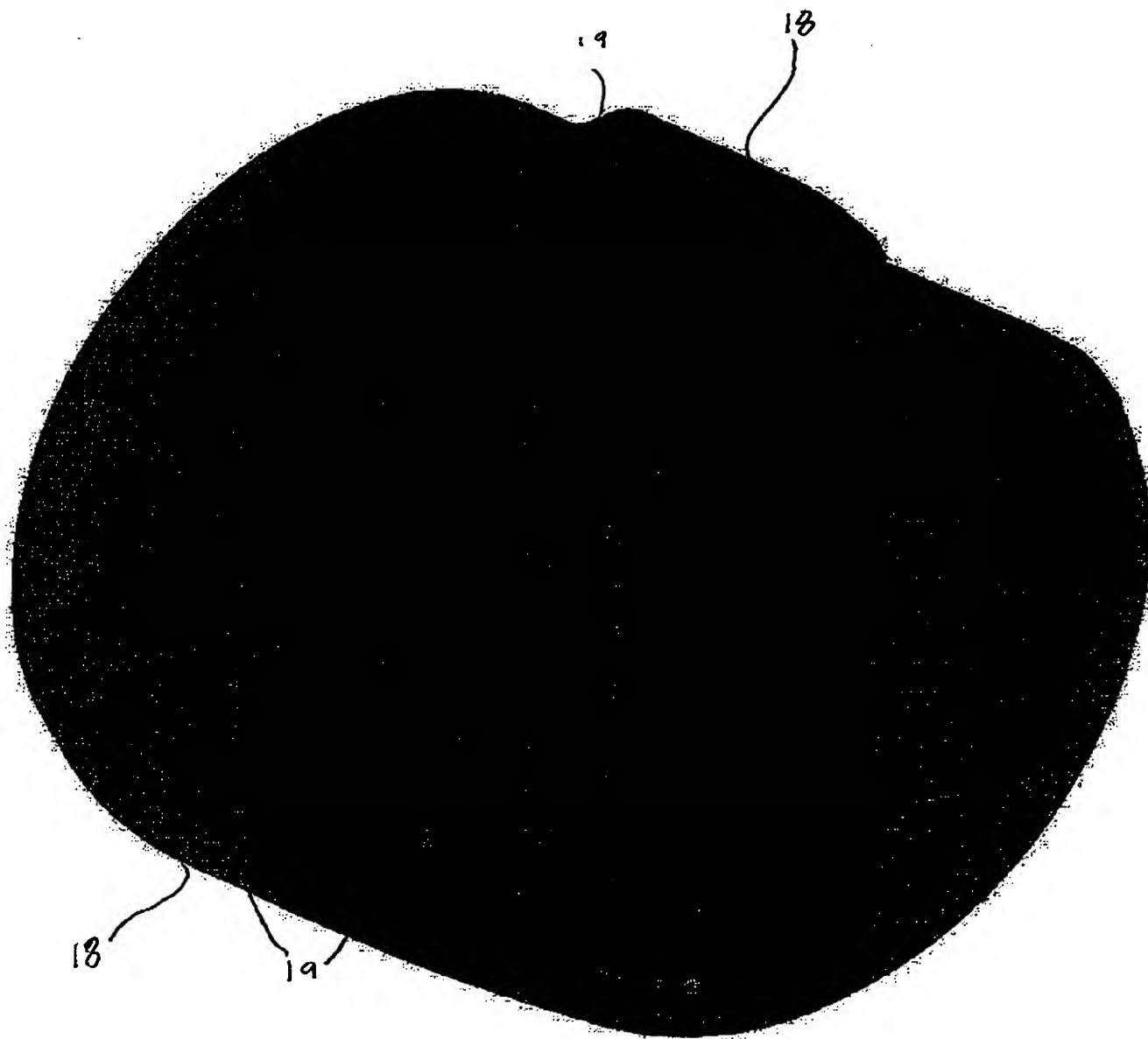


Fig. 2

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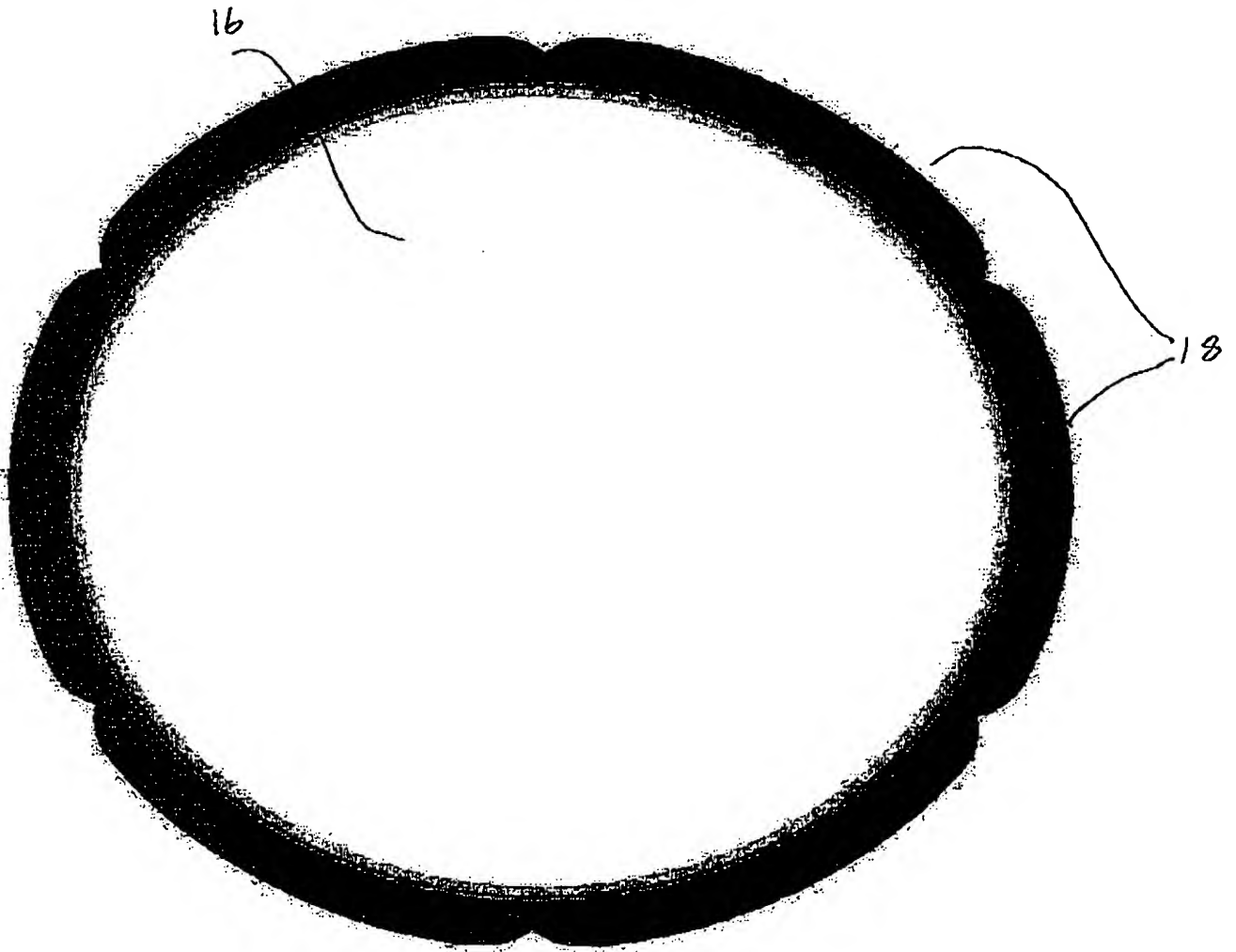


Fig. 3

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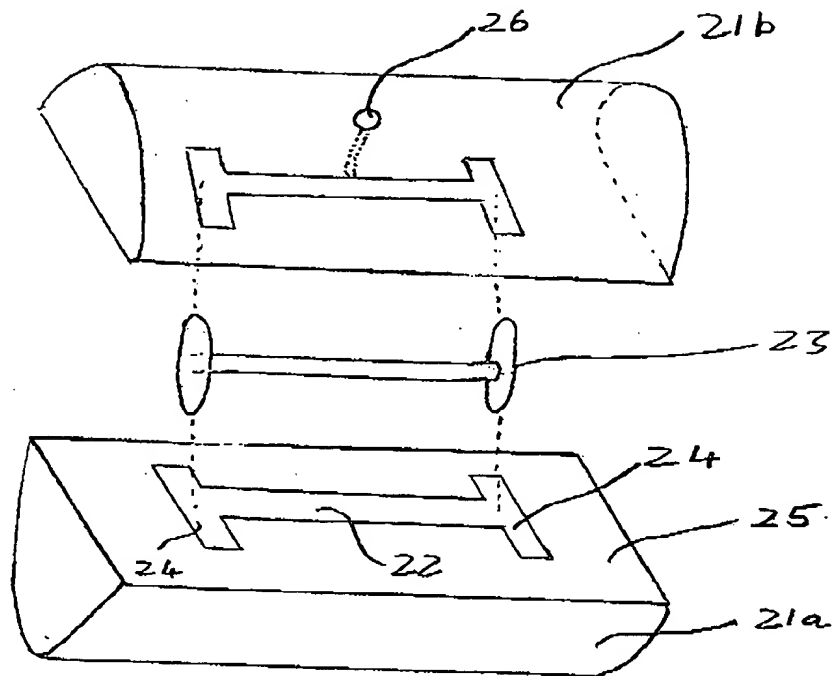


Fig. 4